TEXTILE RESEARCH

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In This Month's Issue

Young's Modulus of Elasticity for Fibers and Films by Sound Velocity Measurements

A new method for determining the elasticity of fibers and films is described. Sound waves are passed through the fiber or film which cause the material to go through rapid stretching and recovery as it vibrates. Measurement of the velocity of sound through the test material (the density of which is already known) makes possible the exact calculation of the elastic modulus. The determination of the elastic modulus of textile materials at high vibrational frequencies is of importance to manufacturers of certain textile products. In some cases, for example rayon in rubber tires, the vibrations are very rapid. (See page 282.)

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Research in the Physical Sciences

"The contrast between American technology in World War I and today, in the volume of technical effort that it can put forth and in the speed with which new problems can be solved, is undoubtedly due to the great growth of fundamental science in this country in the inter-war years." The organization, direction, and support of fundamental research are discussed by Dr. Hugh S. Taylor of Princeton University. (See page 293.)

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Post-War Fabric Demands

The influence of the returning soldier on post-war fabric demands is emphasized and some of the demands that undoubtedly will be made by the returning veterans are outlined. Improvements in fabrics and garments due to the extensive research being carried on by the Government are predicted. (See page 297.)

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Instrument for Testing Fabric Coverings on Airplanes

A new mechanical fabric tester for the rapid determination of the airworthiness of fabric coverings on airplanes has been developed. (See page 300.)

Determination of Young's Modulus of Elasticity for Fibers and Films by

Sound Velocity Measurements

By J. W. BALLOU* AND S. SILVERMAN†
E. I. duPont de Nemours and Company, Buffalo, N. Y.

Abstract

A method for measuring the modulus of elasticity of fibers and films by sonic means is described, and the results of an exploratory study of this modulus in various natural and synthetic fibers and films are given. The method is based on the equation for the propagation of longitudinal (sound) waves in elastic materials, which expresses the velocity of propagation in terms of the elastic modulus and density of the medium. The procedure involves measuring the sound velocity and calculating the modulus, using the proper density value. The modulus so calculated is characteristic of a dynamic, essentially adiabatic, high-loading rate, short period measurement, since a sound frequency of approximately 10,000 cycles per second was used. The range of moduli for common textile materials was from 1×10^{10} to 50×10^{10} dynes per square centimeter.

As the synthetic textile industry has grown from its early days when rayon was considered only as "artificial silk," to the status of a widespread, self-sufficient industry, it has become more and more important to understand and to measure inherent physical properties of these new man-made yarns. This is particularly true of such yarns as those intended for military purposes or for tire-cords, where physical properties are involved which never before were of much importance. At the present time, empirical testing is usually resorted to in the end, for lack of ability of such measurements as the usual stress-strain curve to impart any information which correlates with observed practical performance. Since it was felt that the elastic properties of a string under tension are fundamental characteristics of the system, it was decided to embark upon a research which would develop a technique for measuring the elastic modulus in an unambiguous manner. The modulus

* Now at Underwater Sound Laboratory, Harvard University, Cambridge, Mass.

† Now at Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

A part of this material was included in a paper presented May 13th in New York, N. Y., before the Acoustical Society of America.

likely to be of primary interest is Young's Modulus, defined as

$$E = \frac{\text{Force per unit cross section}}{\text{Elongation per unit length}}$$

In dealing with systems that exhibit both plasticity and elasticity such as fibers and films, the usual methods of measuring Young's Modulus are apt to give results highly influenced by the presence of the plastic component, since in general a low rate of loading is employed. When a load is applied slowly to such a medium, plastic deformation is observed, i.e., one in which complete recovery is not present after the release of the stress. In a good many cases the resultant stretching produces a change of structure, e.g., a change in the molecular orientation; and it is for these reasons that the usual mechanical methods are not adapted to a study of the truly elastic characteristics of fibers and films. Also it is difficult to apply some of the methods; such as those based on compression, impact, and photoelastic effects. To study the elastic component alone requires a high rate of loading so that the deformation is executed very rapidly, thereby minimizing the relaxation and plastic processes. The problem of obtaining this high rate of loading for such measurements was solved by the use of longitudinal vibrations of relatively high frequency, around 10 kc/s; this application of sound was used previously by Meyer and Lotmar [1],[1] but in a considerably cruder and less versatile form than that described in this paper. This method was developed with a view to apply-

[1] Figures in brackets indicate literature references at the end of this paper.

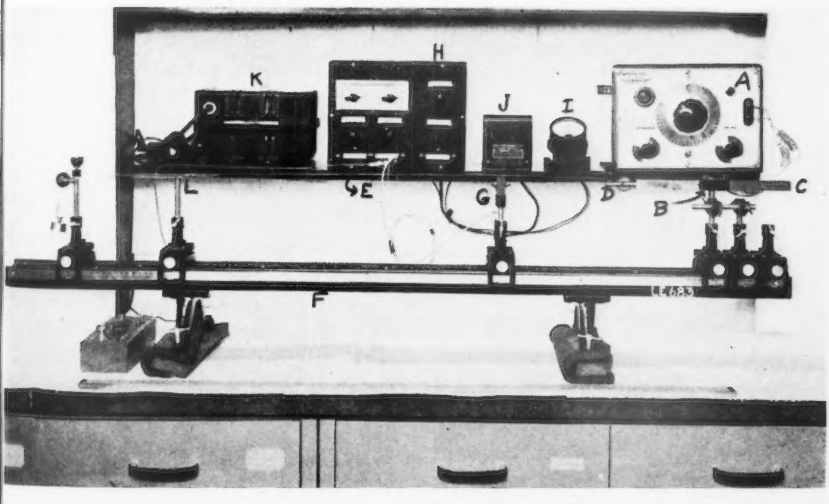


Fig. 1. Apparatus used for determining Young's Modulus of Elasticity for fibers and films by sound velocity measurements. (A) audio oscillator; (B) rochelle salt crystal; (C) steel resonating bar; (D) yarn clamp; (E) yarn sample; (F) optical bench mounting; (G) crystal pick-up; (H) amplifier for pick-up signal; (I) out-put meter; (J) filter to remove 60 cycle from I; (K) voltage regulating transformer for power supply.

ing it to the study of the fundamental properties of fibers and films and it was hoped that correlations between the dynamic modulus so measured and other properties would give useful information, as well as provide another fundamental means of characterizing a structure. This should also be of considerable interest in the study of elastomers; that is, natural and synthetic rubber, plasticized resins, etc. Most measurements reported have been made under relatively low rates of loading; whereas many applications, for example in tires, require high rates. It appears that more work than has been done up to the present would be very worth while; particularly at lower frequencies, which conceivably might give much valuable information on relaxation times and other structural parameters. Because of the preliminary status of our work it is planned to stress the method rather than the results obtained to date and their interpretation.

Method

The method used is based on the expression for the velocity of sound in media which are free to shrink laterally when extended longitudinally, and expand laterally when compressed longitudinally—that is:

$$V = \sqrt{\frac{E}{d}} \cdots \text{Equation 1 [2]}$$

where E = Young's Modulus of Elasticity
d = density of the medium

From this it can be seen that E, the adiabatic modulus, can be calculated if V and d are measured. This is what was done in the present case with continuous fiber samples and very narrow film strips. It was assumed that this formula applied to these materials without any corrections. This is permissible, particularly in the case of the fibers which were usually made up of filaments of a very small cross section. It is a fortunate thing that V is independent of the fiber cross sectional area, thereby making it unnecessary to measure this quantity accurately. This is a distinct advantage not found in the usual methods for measuring Young's Modulus. However, it was necessary to know the density of the fibers and films tested, but the literature provided reliable values in most cases.

As previously mentioned, an experiment of a similar nature was performed by Meyer and Lotmar in which the vibrations were excited by friction both in the test fiber and in a standard fiber with known properties. By varying the length of the standard fiber, the sound frequency produced was made equal to that of the test fiber. From the ratio of the fiber lengths when this condition obtained, the velocity of sound in the test fiber was calculated. This method, while direct, is somewhat inexact, and furthermore requires a standard sample, a musical ear and quiet surroundings. To obviate these requirements and to increase the precision, the method was modified so that standing waves of a definite frequency were set up in the sample and the half-wave lengths measured. Knowing the frequency, the velocity was then calculated.

Remembering the usual relation for wave motion: that

$$V = n\lambda$$

where

V = velocity of sound
n = frequency of vibration
λ = wave-length

we get by substituting in Equation (1)

$$E = n^2 d\lambda^2 = 4n^2 d\frac{(\lambda)^2}{(2)^2} \cdots \text{Equation (2)}$$

The method of measurement can best be understood by reference to Figures 1 and 1A. The source of the longitudinal vibrations is a half wave length bar of steel to the center of which are attached two Rochelle salt crystals. The bar is clamped in the center and the crystals excited by the variable frequency audio oscillator which is tuned to maximum output. The particular bar and crystal combination used resonated at 9.4 kc/s and gave longitudinal oscillations of sufficient amplitude with only a few volts applied directly from the oscillator. At one end of the bar is a clamp for attaching the fiber sample or film strip. The source, along with a pulley and clamp at the other end, is mounted on an optical bench and the sample is run over the pulley and loaded by a weight to give the desired tension or clamped at the desired elongation. Another thin Rochelle salt crystal attached to a support which can move along the optical bench acts both as a reflecting fret and detector of the amplitude of the standing waves when they are set up. The output of this crystal is amplified and read on a meter. As the crystal is moved down the sample away from the source, successive peaks in intensity are noted. What apparently takes place is that the crystal offers a sufficient discontinuity to return some of the energy

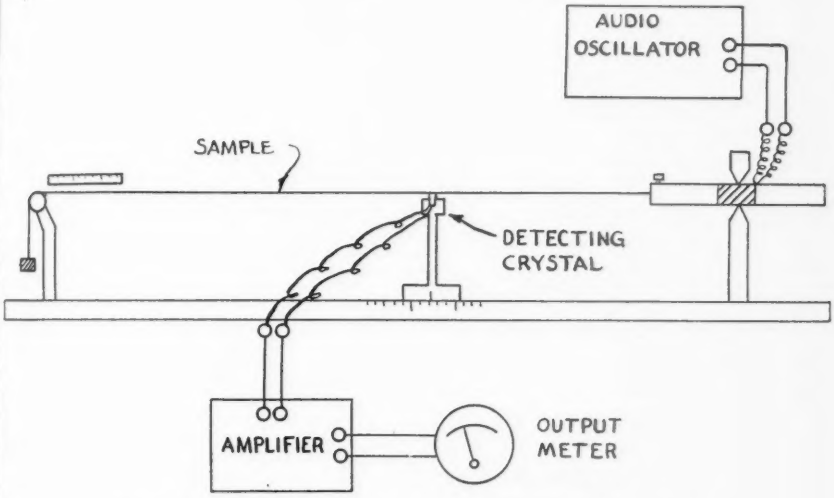


Fig. 1A. Diagram of device for sound velocity measurements.

to the source. When this returned energy is in phase, standing waves are formed and the intensity increase, as shown by the output meter, occurs. To determine the half wave length, the position of the movable crystal support on the optical bench is noted for two successive maxima, the difference then being the required value. This scheme is preferable because any end effects cancel out.

In operating the above set up, the sample is put in under a definite load or elongation. The detecting crystal is adjusted for height so that good contact with the sample is insured. This adjustment is very important and some practice is required in finding the optimum condition. The position of the detecting crystal, the amplifier gain and oscillator output are next adjusted so that a signal of a volt or so appears on the meter. The oscillator frequency is then adjusted for resonance, as indicated by a peak in the meter reading at this arbitrary setting of the pick-up. Next, the crystal is moved along the optical bench until an absolute peak is found, meter readings every 1 mm are taken and the peak accurately located. The crystal is then moved on to the next peak and a similar bracketing measurement made. A small millimeter scale was used for measuring sample elongation under various loads, using a fiducial mark on the sample.

In working with fibers, any twist above three turns per inch was removed before any measurements were made. It was found necessary to load all samples initially by a small amount to get good maxima readings. This was done in all cases and the elongation was calculated using the length at this loading as the original length. In general, cords twisted from strands could not be tested as the surface was too irregular.

In working with films such as cellophane, a strip a few mm wide was cut in the desired direction and put in under a load of 100 g. As before, if the sample was stretched, the length at this load was taken as the original length.

To facilitate routine use of this method, graphs were prepared for each common density used, the modulus being plotted vs. the half wave length at the operating frequency. The half wave lengths encountered in the tests ranged from 5 to 30 cm. It was found practical to train an operator to use the set up for routine testing and it is hoped in the future to be able to adapt the arrangement to a direct reading scheme perhaps by use of a suitable phase meter.

Concerning the accuracy of the results, the following may be said. The peak positions were usually determined easily to ± 1 mm and also it was thought that the frequency was good to ½ percent. This suggests that on the average the absolute results are good to about 3 percent, providing the density figures are correct. Measurements of densities of films by immersion in heavy liquid mixtures indicate that the densities of most regenerated cellulose films are essentially the same. The combined effects of added weight and swelling due to adsorbed water at higher humidities tend to change the density very little as they are both in such a direction as to cancel out. The change in density due to stretching is not known inasmuch as a reliable value of Poisson's ratio for the various materials is lacking. Assuming a reason-

able value for this ratio, however, the change in density due to a 10 percent stretch is of the order of the experimental error in determining the half wave lengths.

As a check on the uniformity and reproducibility of the modulus measurements, seventy-five successive one yard samples of representative viscose rayon textile yarns were tested. In each case the standard deviation was 0.25×10^{10} dynes/square centimeter. As this is approximately the probable error to be expected because of the ± 1 mm uncertainty in determining the peaks, it is concluded that a fair degree of uniformity exists and tests on one sample are representative of the portion from which it was taken.

Results

The range of moduli encountered in the tests made was from 1 or 2×10^{10} to $45\text{–}50 \times 10^{10}$ dynes/square centimeter. Of the fibers measured, it was observed that the highest modulus was obtained in a natural fiber, linen, which had been wetted and dried under tension while the lowest was characteristic of wool and undrawn nylon. Ordinary viscose rayon textile yarns ran from 10 to 30×10^{10} dynes/square centimeter, cellulose acetate yarns somewhat lower and nylons lower still. Regenerated cellulose films, such as cellophane, exhibited very little variation, being all between 8 and 12×10^{10} dynes/square centimeter in the principal grain or machine direction, with values roughly one half these in the transverse direction. Cellulose acetate films averaged lower, around 5×10^{10}, and ethyl cellulose films around 3×10^{10} dynes/square centimeter.

That these dynamic moduli are higher than those obtained by essentially static means is shown by comparative experiments on nylon monofils which indicated that the sound velocity value in this case was about 1.7 times a value obtained by a deflection method under the same conditions. The dif-

TABLE I. Densities of common materials

Viscose Rayon	1.53	[3]
Acetate Rayon	1.28	[4]
Cupra Rayon	1.53	[5]
Nylon	1.14	[6]
Wool	1.30	[7]
Linen	1.50	[1]
Silk	1.25	[9]
Cellophane	1.53	[4]

TABLE II. Moduli of some natural fibers at 60% R.H., 70°F.

Linen	Approx. 2 g.p.d. load.	36×10^{10} dynes/cm²
"	Wetted and dried, approx. 2 g.p.d. load.	46×10^{10} dynes/cm²
Wool and Hair: Three strand wool yarn of about 850 denier was untwisted. Measurements were made on single strands, under the following loads.		
	0.05 g.p.d.	1.6×10^{10} dynes/cm²
	0.12	2.6
	0.24	3.6
	0.35	4.3
	0.50	5.1*

*The value of 5.1×10^{10} is likely to be nearly the true dynamic modulus as checked by values on human hairs.

ference is ascribed to the difference in rate of loading.

Data

Typical results are shown in the following curves. Figure 2 shows the typical results obtained from a commercial bright viscose textile yarn at 60% R.H., 70° F. The effect of stretching on the modulus is indicated. After each stretch, 30 seconds was allowed for reaching equilibrium. The relaxation, curve shown by dotted line, shows that some permanent change has occurred in the yarn, and the lower modulus values for a given extension indicate that this change is in the nature of a relaxation of molecular bonds.

Figure 3 illustrates the modulus vs elongation curve for a DuPont "Cordura" type 1100 denier yarn of about 3.4 grams per denier. It will be noted that this yarn shows a steadily rising slope. This would indicate a constant increase in the rate of reinforcement between adjacent cellulose chains. As in Figure 2, the dotted line shows the modulus plot during relaxation.

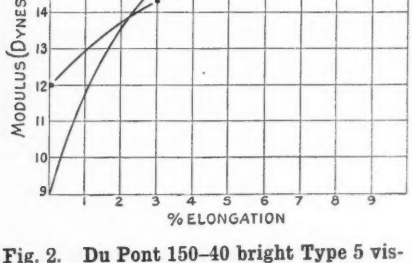


Fig. 2. Du Pont 150–40 bright Type 5 viscose textile yarn, 60% R.H., 70° F.

Figure 4 illustrates the behavior of a standard 75 denier bright "Acele" acetate yarn under elongation and relaxation. The reverse in the sign of the 2nd derivative of the curve, i.e., the modified flex point seems real, as does the minimum modulus value in the relaxation cycle at around 3% elongation.

Some rather interesting observations were made on human hairs. It was our good fortune to have in the laboratory a young woman with shoulder length reddish blond hair which was a heterogeneous mixture of individual red and blond hairs. Of these, the red individuals were definitely finer and younger, and, according to the owner, become coarser and blond as they age. With a fine spirit of cooperation, several nice specimens, some 30 cm long, were provided in each shade. The results were as follows

Red Hair 6×10^{10} dynes/cm²
Blond Hair 7×10^{10} dynes/cm²

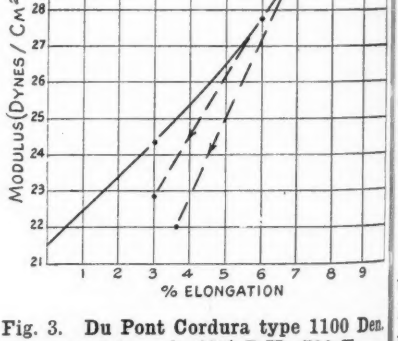


Fig. 3. Du Pont Cordura type 1100 Den. yarn, 3.4 g.p.d., 60% R.H., 70° F.

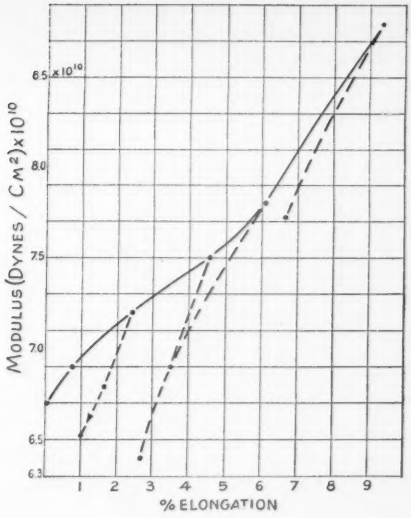


Fig. 4. **Du Pont acetate 75 Den. yarn, 60% R.H., 70° F.**

This showed that the newer hairs were lower in modulus, and somewhat less rigid in molecular structure.

It was noteworthy that an extension of over 20% could be obtained without any increase in modulus. This is in keeping with current theories on wool structure which indicate a highly adjustable structure which can be greatly stretched without reinforcement.

Silk: Some three-strand pure silk thread of approximately 230 denier was measured at 1 g.p.d. and the modulus found to be 19.4×10^{10} dynes/square centimeter at 60% R.H. and 70° F.

Figure 5 gives typical results for nylon, showing the markedly different behavior of drawn and undrawn nylon. It is noteworthy that the drawn yarn has remarkable recovery properties; it is the only material thus far investigated whose relaxation curve follows the extension curve for a large range of elongation. The undrawn polymer behaves much like a viscose rayon textile yarn, exhibiting a permanent change in structure due to stretching, excepting that this change is much more pronounced for nylon.

General

As would be expected, it was found that the general effect of decreasing the humidity and increasing the temperature is to increase the modulus in viscose rayon fibers. There was no appreciable influence of any of several finishes applied to such yarns, whereas boiling in a soap solution tended to lower the modulus.

A series of fiber samples having progressively higher moduli obtained by stretching samples of the same material were checked for orientation and crystallinity by x-ray diffraction and other methods. The modulus was observed to increase with orientation whereas the crystallinity did not change appreciably.

Films

Before showing any results in films it must be mentioned that in the manufacture of regenerated cellulose films like cellophane, the material is subjected to different stresses in different directions. The principal or machine direction necessarily experiences somewhat different conditions in manufacture from those experienced by the transverse direction. Consequently

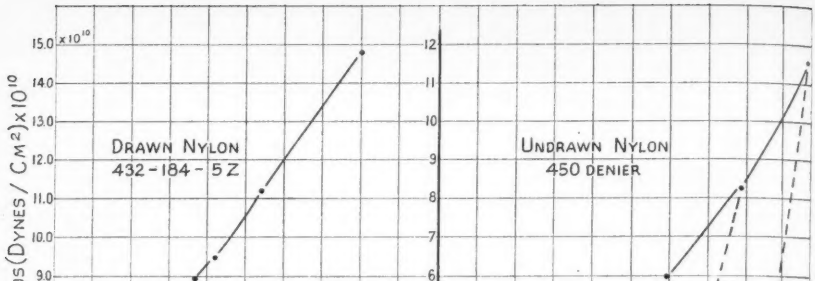
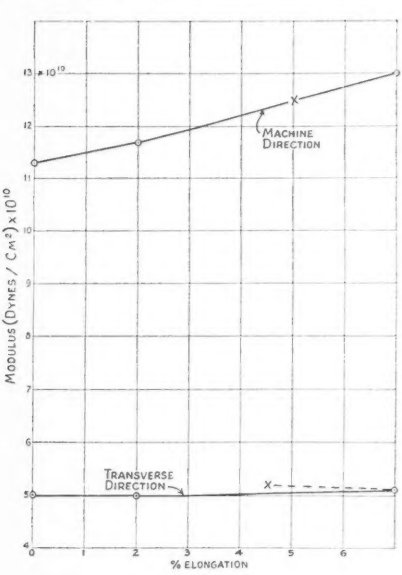


Fig. 5. Typical results for nylon. Illustrates difference in behavior of drawn and undrawn nylon, 60% R.H., 70° F.

different physical properties in the two directions are observed.

Figure 6 shows results with a typical transparent regenerated cellulose film.



The top curve shows how the machine direction modulus varies with stretch and the bottom curve gives the same results for the transverse direction. The anisotropy due to the manufacturing process is evident.

As in the case of fibers, an increase in modulus with decrease in relative

Fig. 6. Typical transparent regenerated cellulose film, 300 gauge, 17½% softener, 60% R.H., 70° F.

humidity and increase in temperature was observed.

Several non-cellulosic films were measured, all of them exhibiting a lower value of the modulus than regenerated cellulose films. In some cases it was found impossible to measure the modulus, no output from the detecting crystal being evident. This was probably due to extreme absorption in these particular materials.

As a check on the variation of the modulus with the direction in the film sheet from which the sample strip is cut, a survey at intermediate angles between the machine direction and transverse direction was made. The results for a regenerated cellulose and cellulose acetate sample are shown in Figure 7. As can be seen, the regenerated cellulose sample shows considerable anisotropy while the cellulose acetate structure is essentially isotropic.

Perhaps one of the most interesting experiments made in the present series is the one in which a correlation between the optical retardation or birefringence and the elastic modulus exhibited by regenerated cellulose film was established. The retardation had been known to vary considerably, under the usual conditions of manufacture, from edge to edge of the sheet. This is caused by the non-uniformity of strain pattern introduced during the drying operation. Strips of film were cut at various points from edge to edge and the modulus and optical re-

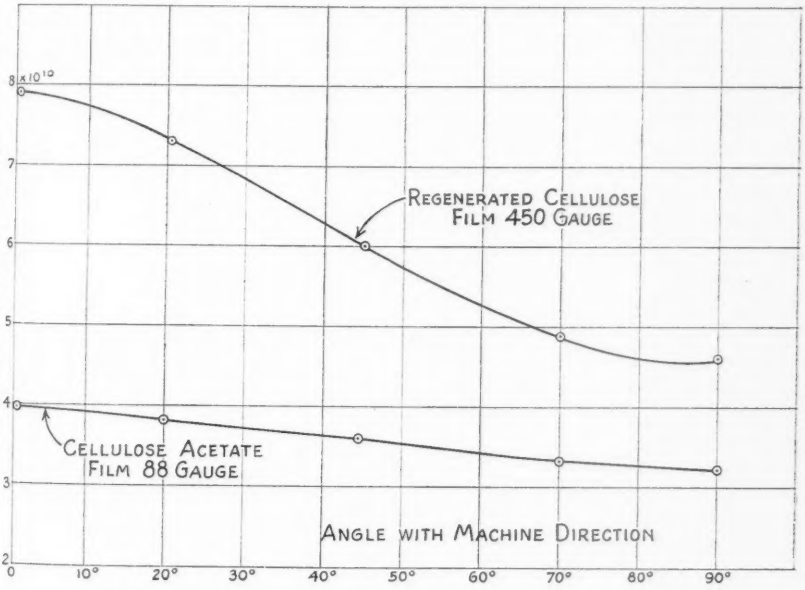


Fig. 7. Regenerated cellulose and cellulose acetate film, 16% softener, 60% R.H., 70° F.

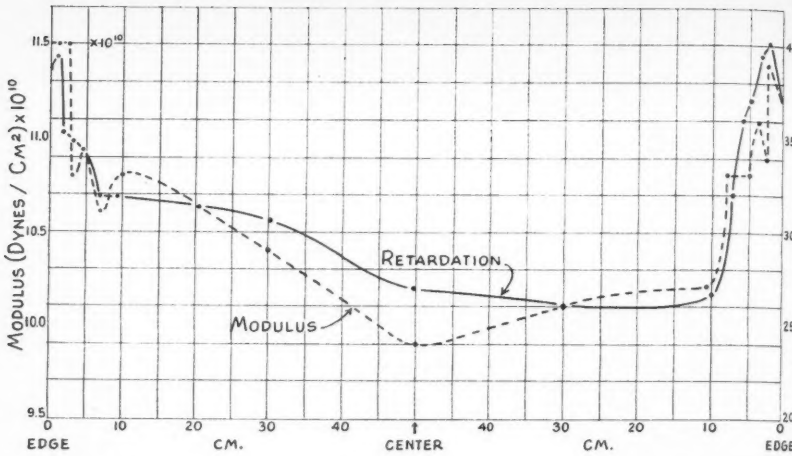


Fig. 8. Regenerated cellulose film, 300 gauge, 13% softener, 60% R.H., 70° F.

tardation measured. The average results are shown in Figure 8 and it is noticed that the correlation is quite marked showing the parallelism between optical and mechanical effects.

Conclusion

As mentioned earlier, the survey of results given is for the purpose of showing applications of the method. No attempt has been made to analyze them in the light of structure, although the implications are obvious in some cases. It is hoped that further work will be fruitful in establishing some useful and interesting relations.

The authors wish to acknowledge the cooperation of the management of the Rayon Department, E. I. duPont de-Nemours Company in permitting this material to be assembled for publication.

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[8] International Critical Tables.

The Organization, Direction And Support of

Research in the Physical Sciences

By DR. HUGH S. TAYLOR*

The following abstract from an address presented by Dr. Taylor, Nov. 13, 1943, before the Autumn general meeting of the American Philosophical Society is of particular interest to the textile industry in view of its aroused participation in research. Dr. Taylor is a member of the scientific advisory committee of the Textile Foundation, and of the Textile Research Institute, Inc. This address appears in full in the Society's "Proceedings," Vol. 87, No. 4.

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"The American nation is in process of assuming, through the power of her military, naval and air forces, and the technological organization requisite to that power, a position of major responsibility for peace and civilization in the post-war era. Adequately to meet the commitments which such a responsibility entails, the United States will, of necessity, be forced to enlarge both political and social horizons and at the same time to develop, to a degree hitherto unrealized, the scientific bases which that enhanced influence in the counsels of the world will, in large measure, require. . . .

"The growth of the educational supply to meet the research demand has led inevitably to steady improvement in the quality of educational and research activity in American colleges and universities in the inter-war years. American science and scientists have, in the main, been prepared for the tremendous calls that the present war has laid upon them. Leaders in the scientific effort have received a generous measure of support from educational foundations. There has grown up as a result, in and out of the universities, centers of research devoted to a group of connected problems. Dr. C. E. K. Mees, of the Eastman Kodak Research Laboratories, classifies such laboratories 'as "convergent" in distinction from the more usual "divergent" laboratories, in which problems of many kinds are studied.' Such a laboratory of the convergent type may well be described, Dr. Mees believes, as a 'research institute,' and it is this type of research institute that he expects to be the most important of the agencies for the production of fundamental science in the future. The research institute is a growth of the last half-century in the organization of research. It has grown out of the specialization of investigators, generally at universities, in some field of work important enough to attract students to the field and resulting finally in the establishment of the laboratory in question as the center for research in the subject. . . .

*Chairman, Dept. of Chemistry, Princeton University.

"To a lesser degree, over the whole country, monetary grants in support of promising research work and research men are producing research institutes convergent rather than divergent in nature, within the framework of existing universities or as separate organizations with some degree of affiliation with college or university. . . .

"Institutes of the type here considered can be in no sense regarded as substitutes for the industrial research laboratory. These latter are essential if the new developments in fundamental science are to be translated into industrial processes and products. The research institute must be regarded, with the university research laboratory, as the principal source of that body of fundamental science which the industrial research laboratory will bring into practical application. The energetic demands for applied science now with us due to war have only served to show, in sharper focus, how the solutions of desired industrial problems are oftentimes delayed by gaps in our fundamental knowledge. In the solution of pressing war problems how often have we to lose time in learning the science underlying the desired application. The industrial laboratory must look in large measure to the university and research institute, even in normal times, for such basic data. The advantage which industry would reap therefrom would lie not so much in the immediate returns from the fundamental research but in the speed and economy of effort with which industry can utilize such effort in the solution of its own practical problems. The contrast between American technology in World War I and today, in the volume of technical effort that it can put forth and in the speed with which new problems can be solved, is undoubtedly due to the great growth of fundamental science in this country in the inter-war years. . . .

The Direction of Research

"It seems reasonably certain that the selection of research directors and research professors will in the long run be most successful if the body responsible for selection consists primarily of scientific men. Breadth of interest within that body of scientists may help to promote wisdom of choice. The important chairs of science in Sweden are filled only after consultation with colleagues abroad. Within one American university at least, the nominations to a research professorship in any one science must be approved by the research committee representative of all the sciences there taught. It is also quite certain that largely non-scientific boards of control with power to formulate scientific programs for both war and peace and with power to prescribe personnel and facilities for those programs, as is true of certain proposals originating in this country from legislative sources, can not conceivably be productive of the scientific direction and potential that the country needs in either war or peace.

The Support of Research

"In the field of industrial research there is no problem of support. Technological progress has revealed, in an ever-increasing measure, that research is the price of industrial development that it can revolutionize the bases of

industry, render obsolete the equipment and techniques of today in the new procedures of tomorrow. Facing a fight for survival by the competition which originates in the research laboratories, individual organizations and cooperating groups are deciding to insure their own financial stability and future by a large premium of research effort. There is abundant evidence that such insurance pays real dividends. . . .

"The support of fundamental research by industries is a problem of great complexity. It has been argued by some that boards of direction of industry have no right to utilize the stockholders' monies in support of scientific research, the bearing of which on the profit-making of the industry is at best arguable and at worst very remote. The legal aspects of such support have been debated on many occasions. The returns to an industrial donor are generally indirect and are normally of benefit to the donor industry and its competitors alike. Industries of great breadth of activity with highly developed industrial research organizations of their own can most easily accommodate themselves to these factors in industrial support of basic research, and seize swiftly for their own advantage the results that accrue from such support. Taking the long-range view and admitting that immediate profits from new discoveries are rare, we must concede that industry does receive benefit from fundamental research in at least two important directions. The supply of adequately trained research workers inevitably increases in centers of intense research activity. The new discovery is as luring as gold in the Yukon Territory. Further, the broadening of understanding that accompanies each new scientific discovery means for the industrial research laboratory a surer, swifter and more economical approach to its own objectives. . . .

"What of the decentralized industries that operate in small, widely distributed units with only a relatively small number capable of maintaining research laboratories for their industrial problems? What measure of support for pure science can they supply? How can they meet the competition from without, to which large industrial research organizations by the breadth of their own research efforts subject the little industry? The answer would seem to lie in a cooperative effort shared in limited amount by each but, in aggregate, large and impressive. It would seem to lie in the development of the research institute, whose main objectives should be (1) the prosecution of fundamental studies in the general field of the pertinent subject, its physics, chemistry, biological and engineering aspects, (2) the dissemination of research information covering scientific and economic aspects of the field, and (3) the training in the methods of research of specially selected personnel at the graduate student level for future positions of responsibility within the industry. Coordinated with an existing educational foundation, such a research institute could produce mutual advantages for both. Each would enlarge its own research horizons, each could supplement the others' activities with personnel and facilities. The advent of the cooperative research institute in the educational centers of the land can be made of significant im-

portance in the general problem of support for research.

"State and Government support of fundamental research is at once the most obvious and at the same time the most hazardous of all the forms of support. By its nature it recognizes that the endowment of research is the concern of all citizens alike and all should share in its burdens and its benefits. Such support tends, at the same time, to enmesh the laboratory with the hurly-burly of competing ideologies or conflicting interests that hamper even the most liberal forms of government and, in the worst cases, tend to destroy that independence of scientific opinion, that autonomy of science, without which it can not fulfil its proper functions to society. We are too near to recent efforts to break the autonomy of scientific effort, to subordinate it to State ideologies and totalitarian control, to be unmindful of its real dangers. . . .

"To go forward to meet the years of difficulty ahead, we shall need the effort of all men of good will, among whom the scientist, by the nature of his calling, must certainly be numbered. The processes of mutual cooperation and assistance among the individual sciences must be multiplied. The isolation of one science from another must become progressively less and less, even though the degree of specialization within a science becomes perhaps greater and greater. This calls for an increasing breadth of culture and of education among the scientists, an increasing dedication by the noblest minds to the forward march of knowledge; but it calls also for a fuller appreciation of the social consequences of that knowledge, a franker recognition of the other factors contributory to true knowledge, to wisdom. 'The modern world,' says Maritain, 'by which I mean that world which is coming to an end before our eyes, has not been a world of harmony between forms of wisdom, but one of conflict between wisdom and the sciences, and,' he adds, 'it has seen the victory of science over wisdom.' Have not we scientists, so to speak, to surrender that victory? We shall not yield our energy, our courage, our diligence in search of truth. We shall but renounce the primacy to which a sick world has thrust us; and we shall gain by our renunciation. In the free world to which we still dare to look forward, with the soldiers and statesmen, artists, humanists, philosophers and priests, we must integrate our scientific skills with the social and spiritual aspects of human life and nature. That goal attained, we shall not lack either direction or support for the physical sciences."

A. S. T. M.

The fall meeting of Committee D-13 of the American Society for Testing Materials will be held on October 18, 19, and 20 at the Park Central Hotel, New York, N. Y.

Effects of Military Research in Textiles Will Create New

Post-War Fabric Demands

The effect of war research on postwar fabric demands was emphasized by John M. Reeves, of Reeves Bros. Inc., before the Southern Garment Manufacturers Association Convention. He dealt particularly with the "fabric-wise" returning veterans.

Mr. Reeves predicted improvements in fabrics and garments due to the extensive research being carried on by the Government, and pointed out that soldiers can tell just how their garments protect them under all conditions and whether colors stand fast or fade and whether their uniforms rip, tear, scuff, snag, rot or mildew. "It is our responsibility—our salvation—to be ready as soon as possible to answer the demands of this tremendous male market which will not only choose for itself the best in work clothing and sportswear, but will exert its influence upon the other millions who stayed home."

Mr. Reeves believes that postwar veterans will demand:

"1. Garments made of fabrics with greater durability. Since wide experimentation and field tests by the armed forces show that cottons have stood up much better than the other fabrics, therefore the better work clothes, chosen for ruggedness and durability, will be made of cotton.

"2. In rainwear, garments featuring a high degree of water-repellency.

"3. More comfortable garments made and styled along lines suited to greater freedom of action.

"4. Garments reflecting a high grade of craftsmanship with more style and better tailoring in even the most utilitarian types of work clothing.

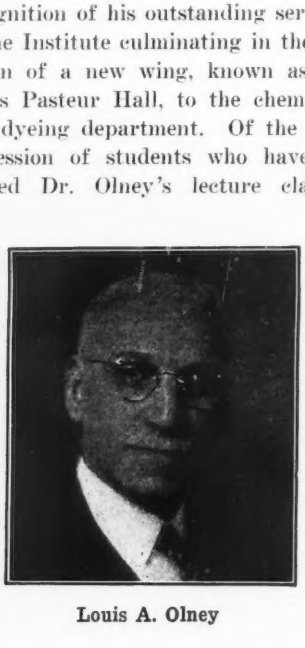
"5. And last, they will want color—color and still more color. O. D. No. 7 may be the most practical and protective coloring for military wear, but the chances are that our boys will have seen so much of it that a wide range of bright fast colors will have a tremendous vogue. These colors must be sufficiently fast to take plenty of perspiration and repeated washings, for both our soldier and the girl he left behind are in agreement on this point."

Mr. Reeves also urged the continuance of postwar research work. "Now we must not only thoroughly understand the place of cotton in future markets, which is secure, but we must also be thoroughly conversant with blends and synthetics. In short, we must know our markets and products and those of our competitors. For millions of servicemen, our customers, we hope, will be returning to civilian life knowing facts about fabrics and garments as never before.

"Let us plan now to aid and abet the cotton fabric consciousness of these returning consumers through widespread factual advertising, informative labeling and the establishment of many dependable brand names," he concluded.

RESEARCH ACTIVITIES

Dr. Louis A. Olney, the "Dean of Education" in the field of textile chemistry and dyeing, has retired after 47 years association with the Lowell Textile Institute where he was professor and head of the department of chemistry and textile coloring. The Board of Trustees has conferred upon him the title of Professor Emeritus in recognition of his outstanding services to the Institute culminating in the addition of a new wing, known as the Louis Pasteur Hall, to the chemistry and dyeing department. Of the long succession of students who have attended Dr. Olney's lecture classes,



Louis A. Olney

there is probably at least one representative in every dyeing and finishing plant in the country, as well as a long list of those who have gone with dyestuff and chemical manufacturers, testing laboratories, etc. As directing editor of the *American Dyestuff Reporter,* since its inception in 1920, Dr. Olney directed an editorial campaign which resulted in the establishment of the American Association of Textile Technologists in 1921. Dr. Olney is also a member of: American Chemical Society, Textile Research Institute, Inc., American Institute of Chemical Engineers, American Institute of Chemists, American Association for the Advancement of Science, the British Society of Dyers and Colourists and the British Society of Chemical Industry.

Luther H. Hodges, vice president and general manager of Marshall Field & Company in New York City, has been appointed Price Executive of the Primary Products Price Branch of the Office of Price Administration's Consumer Goods Price Division. The Primary Products Price Branch is responsible for the pricing of cottons, woolens, rayons, finished goods and various types of fibers. Mr. Hodges has had 25 years experience in the textile field. Immediately after receiving his A.B. degree from the University of North Carolina, he went with the Marshall Field Company. He has worked for this company in various capacities and is now vice president and general manager in charge of the manufacturing and sales of textiles. He is a director of the Textile Research Institute, Inc., and a member of the Institute's executive committee.

The Fall term of the Textile Evening High and Trade School, 351 W. 18th St., New York 11, N. Y., will begin on September 11th. Separate

classes for beginners and advanced students are given in cloth analysis, design, testing, dressmaking, illustrating, and converting in the textile field, as well as technical subjects in electricity, machine shop work, machine drafting, applied science, and applied mathematics. All instruction is free of charge. Students may register for technical subjects between six and ten after September 18th. For further information apply to Hyman Hirsch, Teacher-in-charge.

Postwar textile position of the industry will be surveyed during a symposium which will be one of the features of the annual meeting of the American Association of Textile Chemists and Colorists when the Association resumes its annual meetings, cancelled since the start of the war, at Atlantic City, N. J., October 12 to 14 inclusive. The 3-day program is being arranged for the exchange of technical information among the Association's 3,000 members. Dr. Miles A. Dahlen will preside over the symposium the subject of which is "The Textile Chemist in the Post-war World." Included among speakers will be: Dr. Samuel C. Lind, dean of the Institute of Technology, University of Minnesota and former president of the American Chemical Society; Dr. Hugh S. Taylor, chairman of the department of chemistry, Princeton University; and Andrew Fraser, Jr., of the War Department.

Alabama Cotton Manufacturers Association will help the Alabama Polytechnic Institute, which was forced to close down a few weeks ago because of a lack of instructors, to reopen for short courses. At a recent meeting, the executive board, presided over by George Elliott of Huntsville, president of the association, authorized the appointment of a committee to assist the college in obtaining instructors. According to Hugh Comer, president of Avondale Mills, the textile school at Auburn had operated successfully for about a year before having to close its doors. Pupils had been recruited from Alabama cotton textile mills for technical courses of eight weeks duration and then returned to their respective plants for upgrading.

Edward P. Tastrom has been appointed textile editor of *The Journal of Commerce*. He succeeds John L. Severance who left August first to become secretary to the Association of Cotton Textile Merchants of New York.

An expanded program in Textiles is offered by Simmons College, Boston 15, Mass., as part of the regular four-year college curriculum in the School of Home Economics. The program is designed to prepare students for work in the textile laboratories of manufacturing plants, retail stores, and commercial testing houses. It also prepares for textile research and for work in the educational departments of textile industries. Walter Hamburger, Director of the Fabric Research Laboratories in Boston, will teach an advanced course in textile technology. The physical, chemical, and optical analysis of fibers, yarns, and fabrics will be studied. The statistical analysis of data and the many problems related to the use of standard textile testing equipment will be emphasized, as well as the application of findings to individual consumer problems.

RESEARCH AIDS

Instrument for Testing Fabric Coverings on Airplanes

An extensive test and calibration program has been conducted by the National Bureau of Standards on a new mechanical fabric tester developed by the Civil Aeronautics Administration. This work has resulted in the refinement of the instrument which determines the airworthiness of doped fabric aircraft covering. It is expected that this mechanical method will supplant the method in which the inspector judges airworthiness by his ability to push his thumb through the fabric.

The instrument operates on the same principal as the automatic center punch. The foot of the instrument is held against the surface to be tested and a steadily increasing pressure is applied, thus compressing a "firing" spring. When the spring has been compressed a predetermined amount, it is released by means of an automatic trigger and drives a hammer against a plunger which impinges upon the surface being tested. The energy of impact was obtained by measuring the indentations produced by the plunger in a block of lead which replaced the test surface.

In studying the instrument, test panels were prepared from different weights of cloth, both new and chemically deteriorated to known extents, and coated with good, semi-brittle, and very brittle dope in different amounts. Impact tests were made on all panels while in equilibrium with air having a temperature of 73° F and a relative humidity of 50 percent, and on some panels while at temperatures of −40° F and 160° F.

The impact energy required to drive the plunger through cloth coated with good or semi-brittle dope at 73° F correlated well with the breaking strength of the doped cloth. Doped cloths were stronger and more resistant to penetration by impact as the weight of the dope increased. Very brittle dope was readily detected by ringworming caused at low impact energy. Tests of fabrics at −40° F and 160° F showed the value of the instrument for studying the changes in doped cloths with temperature. Cloths coated with both good and semi-brittle dope became very brittle at −40° F and were penetrated at low impact energy. The cloths coated with semi-brittle dope became pliable at 160° F and more impact energy was needed for penetration than at 73° F.

Testing airworthiness of the fabric coverings on an airplane.

Twelve of the instruments have been designed and built by the Technical Development Division of the Civil Aeronautics Administration and calibrated in the Textile Section of the Bureau. These have been distributed to interested organizations in order to obtain comments from field inspectors with regard to the instrument and its use in detecting unairworthy fabric coverings on airplanes.

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Factors Affecting Cost of Spinning*

Recently F. P. Sheldon & Son of Providence, R. I. issued a pamphlet entitled, "An Investigation of the Influence of Ring Size, Bobbin Diameter, and Spindle Speed on the Spinning Process and Their Effect on the Overall Cost of Spinning."

The textile manufacturer who is planning to modernize his equipment early in the postwar era will be faced with the problem of not only selecting the best types of equipment, but also incorporating in the equipment the specifications best fitted to his needs. This problem as applied to the specifications of spinning equipment—ring sizes, bobbin sizes, and spindle speeds —has been approached by F. P. Sheldon & Son in a novel manner.

They have plotted for single cotton yarns from 10s to 100s a series of eight charts by which the factors of ring size, bobbin diameter, and spindle speed are correlated for optimum spinning conditions to yarn by count and staple length. The basic information as to yarn strength has been taken from their well-known charts No. 6 and 6A showing yarn strength in pounds (skein break) against yarn count for various staples of carded and combed work; the optimum spinning condition is measured by the tension of the yarn during spinning. By analysis of the chart for any yarn of known staple length, the various combinations of ring size, bobbin size, and speed that will allow in any case good spinning can be determined.

The report also has tables showing for acceptable combinations of ring size, bobbin diameter, and spindle speed the total cost of typical weekly spinning productions for an average mill; the important feature of interest here is the evidence that although large package spinning is in itself a money-saving proposition the increase in cost of power and the higher unit fixed charges in many cases affect these savings.

Those manufacturers who have not in the past been cognizant of the substantial cost of the increased power requirements and higher fixed charges per pound due to large package spinning as brought to light in this investigation will find it worthwhile to study this report.

* Reviewed by Elliot B. Grover, N. C. State College Textile School.

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Properties of Fiberglas Fibers and Fabrics

Data on the use of Fiberglas-reinforced plastics for structural parts of aircraft, recently revealed by the Materiel Command of the U. S. Army Air Forces, emphasizes the increasingly important role Fiberglas-plastics combinations are likely to play in innumerable applications where light weight and high strength, coupled with ease of fabrication, are required. The fol-

lowing data appeared in "Supplement to Plastics New Letter, June 19, 1944."

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Fiberglas fibers are the basis of all Fiberglas materials. They are incombustible and possess high dimensional stability. At maximum stress they show an elongation of up to 4 percent. The individual fibers are non-hygroscopic and non-absorbent. Moisture adsorption is less than one percent by weight. Data on the Fiberglas fibers that are the basis of all Fiberglas materials employed for plastics reinforcement, are contained in Table I.

Continuous filament fibers Nos. 22 and 28 are twisted and plied into yarns which in turn are woven into fabrics, the usual form in which Fiberglas is employed to reinforce plastics. Fiberglas Flock may also be dispersed in the resin and used in combination with a cloth, to provide additional lateral reinforcement. Data on Fiberglas cloths available for plastics reinforcement are given in Table II.

Flexibility and high tensile strength of Fiberglas cloths are maintained at high temperatures. The all-glass cloths are completely incombustible except for the fiber lubricant. They are non-hygroscopic, and are resistant to mildew and decay. They are unaffected by most acids, corrosive vapors and oils.

Note: All strength values in these tables are given only as a guide; not as a specification. The values are subject to variation, dependent upon method of measurement, etc. Fiberglas is manufactured by Owens-Corning Fiberglas Corporation.

TABLE I. Fiberglas Fibers

Continuous Filament Fiber	Fiber Diameter (average)	Fiber Length (average)	Approximate Tensile Strength (Lbs. per sq. inch)
Number 22	0.00022"	Limited only by packaging	375,000
Number 28	0.00028"	requirements	275,000
Fiberglas Flock	0.00005"	Measurable in millimeters	Estimated over 1,000,000

TABLE II. Fiberglas Fabrics

Cloth Number	Average Thickness	Weight (ounces per sq. yard) Warp	Minimum Directional Breaking Strength (lbs. per in. width) Warp	Fill
108	.002"	1.6	70	40
112	.003"	2.2	100	70
116	.004"	3.4	160	100
127	.007"	6.4	300	200
140	.010"	8.5	430	290
148	.012"	10.9	520	360
162	.015"	12.4	660	450
*OC-64	.011"	9.0	850	5

* uni-directional cloth, i.e., glass warp, cotton fill.

ABSTRACTS

Members of Textile Research Institute, Inc., desiring complete copies of articles abstracted may obtain photostat copies at cost by addressing the Institute's office, 10 East 40 St., New York 16, N. Y. The price of a photostat negative is seldom more than 30 cents per page of original text.

Translations of articles appearing in foreign language publications and abstracted in TEXTILE RESEARCH, *will be furnished at cost when the original publication is obtainable.*

A list of periodicals abstracted in TEXTILE RESEARCH *and the abbreviations used appeared on page 32 of the January, 1944 issue of* TEXTILE RESEARCH.

ANALYSIS: TESTING: LABORATORY METHODS

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Mercury in Textiles

Determination of mercury in textiles mildewproofed with organo-mercuric compounds. D. A. Shiraeff. *Am. Dyestuff Reptr.* 33, 310–315 (July 17, 1944).

The present importance of the organo-mercuric compound method for rendering textiles mildewproof makes a satisfactory analytical method for such compounds in fabric desirable. Currently accepted but unofficial methods for mercury determination are due largely to the volatility of mercury and its compounds, cumbersome at best and of questionable reliability at worst. A new method has been developed which is consistent, accurate and rapid, not more than ten minutes per sample being required. The shredded sample to be analyzed is extracted with ether saturated with HCl, the ether evaporated, chloroform and water added, and the result titrated with Dithizone solution (diphenylthiocarbazone in chloroform). In the presence of mercury the chloroform layer is colored orange when Dithizone is first added; the end point is reached when the chloroform layer acquires a slightly greenish dark brown color. The Dithizone solution is standardized by titration against standard mercuric chloride solution to an end point identical with that obtained with the test sample. Results are caluculated in terms of percent mercury on the weight of the sample.

Temperature Measurements

Methods of measuring temperature. Anon. *Silk & Rayon* 18, 274 (Mar. 1944).

The constructional details and principles of operation of maximum and minimum thermometers are described. For great accuracy in temperature measurements the platinum resistance thermometer is recommended. Measurement can be made up to 500° C with an error not exceeding 0.01° and up to 1300° C within 0.1°. This thermometer consists of a fine platinum wire wound on mica and protected by a glass or porcelain tube. The wire is connected into a wheatstone bridge. The principle involved is the variation of electrical resistance with temperature according to the law $R_t = R_o (1 + at + bt^2)$, where: R_t is the resistance at t°C.

R_o is the resistance at zero, a constant

a and b are constants.

The constants are evaluated by measuring the resistance at the boiling and freezing points of water and at the boiling point of pure sulphur, 444.53° C.

CHEMICAL AND PHYSICAL RESEARCH

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Color

Small color differences in the ceramic industry. I. A. Balinkin. *Am. Dyestuff Reptr.* 33, 271–3 (June 19, 1944).

Since the color of ceramic ware as it comes out of the kiln is final, it is of great importance to know the factors affecting color variation and to control them. Methods of color standardization in the ceramic industry include comparison with standard color plates, use of the Hunter Reflectome-

ter, comparison with a spinning disc having colored segments of adjustable area, and various other colorimetric devices. The trained shader will however by eye alone grade more per hour satisfactorily and at less cost than any other existing method. An experiment with color tolerance boards prepared with three colors each arranged in series of color differences of from one to five judds showed that the most desirable color difference was not necessarily the smallest color difference; e.g., a 2.2 judd difference for light green was more "desirable" than a one judd difference. The averages of the numerical values of the three colors used (pink, light green, and tan) as chosen by forty-six observers were very close, showing that Judd's formula is applicable in different domains of the color space. In terms of color space "shade" may be defined as a part of a color solid bounded by a closed surface so that the maximum separation of any two points on such surface does not exceed three judds. In order to standardize shades and reduce the number of shades necessary there was constructed a mechanical model representing in a color space the color distribution of several production runs for one glaze, shade being represented by a sphere three judds in diameter within this space; different shades are allocated in the space by picking out different portions of it of approximately the same spherical volume, the centers giving the desired shade standards. This process is lengthy and it is much more desirable from a practical standpoint to reduce the possibility of color variation in manufacture; it has been found possible by means of a "color uniformity control equation" which takes into account the thickness of the glaze, the temperature of firing, and the intrinsic property of the glaze to change color with increasing glaze thickness, to reduce the number of shades for all glazes to not more than three.

Ostwald Color System

Symposium on the Ostwald color system. Foreword. D. B. Judd. *J. Opt. Soc. Am.* **34**, 353–354 (July, 1944).

In a foreword to publication of four papers that form a symposium on the Ostwald color system, it is pointed out that while the Ostwald system has been described in extraordinarily great detail by its originator, few critics have had the patience or time to go through them to get out the details. Now, however, adoption of I.C.I. standard colorimetric conventions has made it possible to test the conformity of the charts or atlases built up to material samples to represent the Ostwald principles with those principles as stated by Ostwald. The purpose of the symposium is to present sympathetically a factual summary of the Ostwald color theory and its implications, together with a technical and practical evaluation of the most recent set of color standards arranged according to that theory. The papers of the symposium give not only the aims toward which Ostwald was striving, but also the degree to which it has been found possible to attain those aims, and some idea of their practical value.

Philosophy of the Ostwald color system. Herman Zeishold, *J. Opt. Soc. Am.* **34**, 355–360 (July, 1944).

Ostwald approached the subject of color science by first determining its position in the natural system of the sciences. This paper discusses Ostwald's philosophy and the development of his thinking in regard to color science.

Analysis of the Ostwald color system. Carl E. Foss, Dorothy Nickerson and Walter C. Granville. *J. Opt. Soc. Am.* **34**, 361–381 (July, 1944).

The information contained in the several formulas, 11 figures, and 7 tables of this paper allows the reader to follow the development, in terms of the I.C.I. system, of specifications for an ideal Ostwald color system. The study shows that production of samples to represent such an ideal Ostwald system is not possible. Ostwald himself made compromises in producing the charts, probably without realizing the degree, since he worked in a day before accurate color specification was an everyday affair. To develop specifications for a series of Ostwald samples that will employ the widest use of existing color gamuts, choice must be

made between equality of hue spacing and complementarism of opposite triangles, and abandonment must be made of the quantitative aspect of the fundamental Ostwald equation White + Black + Color = 1. However, specifications are developed in the paper which preserve the general concept of monochromatic triangles with constant dominant wave length, the concept of complementarism of opposite triangles, and the concept of constant chromaticity in each shadow series.

Colorimetric specification of the color harmony manual from spectrophotometric measurements. Walter C. Granville and Egbert Jacobson. *J. Opt. Soc. Am.* **34**, 382–395 (July, 1944).

In 1942 a collection of 680 color chips, based on the practical specifications of the previous paper, were developed by Carl E. Foss for the Container Corporation of America in a publication known as the *Color Harmony Manual*. The paper presents for these chips a 5-page table containing standard colorimetric data determined from spectrophotometric curves. The data are also given in diagrams so that theeir high degree of conformity to the selected Ostwald principles is readily seen, also a comparison to earlier production of color chips based on the Ostwald system. From the data it is concluded that the chips in the *Color Harmony Manual* represent the closest approach to date of the ideal abridged Ostwald system.

Application of the Ostwald color system to the design of consumer goods. Faber Birren. *J. Opt. Soc. Am.* **34**, 396–399 (July, 1944).

The author has been active as a color consultant to industry for many years and presents his own experience with the Ostwald system, discussing a few of Ostwald's more obvious and useful findings in the field of color harmony.

Hydrogen Bonds and Viscosity

The hydrogen bond. J. Newton Friend. *Chemistry and Industry* **19**, 179 (May 6, 1944). C. E. Kendall. *Chemistry and Industry* **23**, 211 (June 3, 1944).

These two letters to the editor are of interest to anyone concerned with viscosity. Both authors emphasize the fact, often overlooked, that the hydrogen bond has a profound influence on the viscosity of a compound. Kendall presents data illustrating the tremendous difference in viscosity exhibited by compounds of the same molecular weight if in one case multiple hydrogen bonds are possible. For example, n-heptane has a molecular weight of 100 and a viscosity of 0.412 c.p., while glycerol has a molecular weight of 92 and a viscosity of 830 c.p. Illustrations are also given of the decrease in viscosity when substituents are introduced into a compound that prevent hydrogen bonding.

Efficiency and Toxicity of Mildewproofing Treatments

Report on a study and the development of a mold resistant treatment for leather. R. M. Lollar. *J. Am. Leather Chem. Assoc.* **38**, 12 (Jan. 1944).

Report on toxicity studies on preservative bearing leather. R. M. Lollar. *J. Am. Leather Chem. Assoc.* **38**, 203 (June, 1944).

Report on preservatives in army dubbings. H. S. Greene and R. M. Lollar. *J. Am. Leather Chem. Assoc.* **38**, 209 (June, 1944).

In the first paper, paranitrophenol, parachlorometaxylenol, "Preventol I", and "Shirlan Extra" (salicylanilide) are recommended as effective in preventing the growth of mold and non-irritating to human skin. Forty materials were studied. Specimens of leather were drummed with a solution of each material, dried, washed, innoculated with an aqueous suspension containing *Chaetomium Globosum* and common species of *Penicillia* and *Aspergilli*, and incubated at 95–100° F and 85–95 per cent R.H. for periods of four weeks and up. Patch tests were made on human skin. Chlorinated phenols were not very effective. Organic mercurials were effective, but irritative to the skin. The second article reports that dogs and horses were not harmed by wearing harness containing the following preservatives in effective concentrations: pentachlorophenol,

paranitrophenol, salicylanilide, chlorosymmetrical-xylenol, 2,4,5,-trichlorophenol, tetrachlorophenol, 2-mercapto-benzothiazole, 5,5′-dichloro 2,2′-dihydroxy diphenylmethane. In the third of these studies, 16 compounds and mixtures were incorporated in Army shoe dubbing, which was then used to treat leather. Specimens were inoculated and incubated as above, and patch tests were made. Paranitrophenol, parachlorometaxylenol, pentachlorophenol, and tetrachlorophenol are recommended as effective and nonirritating.

The Plastic-Elastic Scale

Position of the rubberlike state on the plastic-elastic scale. J. M. Buist and R. C. Seymour. *Rubber Chem. Tech.* **17**, 366–91 (Apr. 1944).

Analytical and integrative methods show Young's modulus and the coefficient of viscosity are insufficient to characterize the deformation of rubberlike materials. A special case of the Scott-Blair equation for extension at a constant rate has been suggested:

$$\psi' = S\sigma^{-k'}\sigma^{k'-1}$$

where ψ' and k′ are constants. This has been applied to the rubber-like state of natural rubber, Neoprene-GN, Butyl rubber, and Novoplas-A in the raw state, and after mastication, vulcanization, and reinforcement.

X-Ray Structure

Observations on the X-ray structure of rubber and the size and shape of rubber crystallites. S. D. Gehman and J. E. Field. *J. of Applied Phys.* **4**, 371–9 (Apr. 1944).

Vulcanized rubber is composed of a cross-linked network of chain molecules, segments of which are sufficiently free and mobile in localized regions to form a crystal lattice upon stretching. The crystallites thus formed represent an automatic molecular mechanism for re-inforcement and are analogous to particles of re-inforcing pigment which increase the modulus, strength, and tear resistance. These effects depend upon the number of particles present and their size and shape. X-ray determinations were made of the crystallite sizes in a series of vulcanized gum stocks using the Scherrer method but calculating the diffraction broadening by the formula proposed by Taylor. Evidence was found that the crystallite size distribution was heterogeneous and included small crystallites which broadened the base of the diffraction peaks. It could be shown that a high degree of crystallinity in a compound was associated with small crystallite size. Both of these factors combine to give high modulus stocks. For different cures with a given rubber compounding formula, there is a definite correlation between the amount of combined sulfur and the crystallite size. This indicates that irregularities in the structure caused by the combined sulfur tend to limit the crystallite growth. This interpretation is preferred although the experimental evidence is not decisive as to whether or not lattice distortion contributes to the width of the diffraction spots. Significant conclusions can be drawn from the work in regard to crystallite formation in stretched rubber and effects of crystallites on the physical properties.

Artifical Latices

Artificial latices. E. W. Madge. *Rubber Chem. Tech.* **17**, 533–40 (Apr. 1944).

Various procedures for the preparation of artificial latices from the solid plastic are described. Particular attention is given to the machinery necessary for such work. General properties of an artificial latex are enumerated as well as the general properties of the film from such an artificial dispersion. Also a brief discussion of synthetic latices is included.

Elasticity of Polymers

The elasticity of a network of long chain molecules. II. L. R. G. Treloar. *Rubber Chem. and Tech.* **17**, 296–302 (Apr. 1944).

The method of Wall for elasticity of a three-dimensional network of long chain molecules is extended to the most general type of homogenous deformation of rubberlike materials. An equation is derived for the work of deformation of the three

principal strains. The application of the equations to particular problems illustrates their usage.

Chlorination of Wool

The action of halogens on wool. Part 1. Factors influencing the amount of halogen absorbed from solutions in carbon tetrachloride. C. S. Whewell and A. Selim, *J. Soc. Chem. Ind.* **63**, 121–123 (Apr. 1944).

The adsorption of chlorine by wool from solutions of the gas in dry carbon tetrachloride is affected by the time of adsorption, concentration, bulk ratio, temperature, and the regain of the wool. The amount of chlorine adsorbed depends on the type of wool and on any chemical treatment to which it may have been subjected, reagents causing deamination having much greater effect than those which attack the disulphide linkings.

Surface-Active Agents

Sodium alcohol sulfates—properties involving surface activity. E. E. Dreger, G. I. Keim, G. D. Miles, Leo Shedlovsky, and John Ross. *Ind. Eng. Chem.* **37**, 610–17 (July, 1944).

The preparation and properties are described for alternate members of a homologous and of an isomeric series of purified sodium salts of secondary alcohol sulfates, containing from 11 to 19 carbon atoms, and for a straight hydrocarbon chain with the sulfate group in various positions. The purified sodium salts of the primary alcohol sulfates with 10, 12, 14, and 16 carbon atoms are also examined. Measurements have been made of the surface tension and foaming, wetting and detersive properties of solutions of these compounds in water and with added electrolytes. Solubilities of sodium salts of the secondary and primary alcohol sulfates studied are reported at 5° intervals from 20° to 40° C. The data are discussed from the point of view of correlating changes in the properties involving surface activity when the structure and molecular weight of the compound are changed.

BLEACHING: DYEING: FINISHING

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Continuous Peroxide Bleaching

Procedure and equipment for bleaching cotton piece goods with peroxide by the continuous method. D. J. Campbell. *Am. Dyestuff Reptr.* 33, 293–297 (July 3, 1944).

Cotton fabric in rope or open width form may be bleached by the "continuous" method. This consists of two steps, each comprising three basic operations, viz., (1) saturating the cloth with treating solution, (2) heating the cloth to the required reaction temperature by contact with steam and (3) storage without heat loss for the required reaction time (one hour). When plain goods are being bleached the goods are first given a treatment with caustic soda, then heated and stored; if the goods are dyed, then saturation with 0.5 to 1.0 volume hydrogen peroxide takes the place of the caustic treatment. In either case the second part of the procedure consists of saturation with 0.5 to 1.0 volume hydrogen peroxide and subsequent heating and storing. Within fairly narrow limits the optimum concentrations of treating solutions and optimum time and temperature of treatment will depend on the fabric construction and the degree of whiteness and absorption desired. A typical processing formula for plain goods might be (a) saturation with 3 per cent caustic soda solution, (b) storage at 212° F for 45 minutes, (c) saturation with 0.5 volume hydrogen peroxide with pH brought to 10.5 to 10.8 by the addition of sodium silicate, (d) storage at 205 to 210° F for one hour. Continuous processing is effected by the use of a heating chamber in the form of a U tube 30 to 40 feet in overall length and storage chambers of the J piler type of sizes varying to meet different production rates. Laboratory data, confirmed in practice, shows that bleaching increases absorbency; whereas 45 minutes are required to produce absorbency with a caustic treatment alone, 10 minutes in caustic will give the same degree of absorbency if followed by even dilute peroxide treatment. If 0.5 volume

peroxide is used, preliminary caustic treatment must be carried out for one hour to obtain complete mote removal. In bleaching with vat dyed colored yarns present the pH is kept at 10.4 to 10.6 and the temperature at 205° F; in the presence of naphthol dyes still milder conditions are employed, pH 10.0 to 10.4 and temperature 190° to 195° F. In plant operation bleaching speeds up to 190 yards per minute are being realized, with greater speeds probable. Nine ranges are now in operation with an approximate total production of six million yards of bleached goods per week. The overall cost picture is favorable.

Dyeing Rayon Cakes

The dyeing of viscose rayon yarn in cake form. C. M. Whittaker. *J. Soc. Dyers and Colorists* **60**, 109–13 (May, 1944).

The dyeing of rayon in cake form presents definite advantages in efficiency and quality. Development of methods for wet processing rayon in cake form has progressed to such a point that Cortaulds, Ltd., has practically stopped delivery of viscose in skein form. The machine evolved for dyeing cakes is a modification of the conventional package machine, with expansion tank and two-way circulation; the smallest machine has a capacity of 25 one pound cakes, the smallest number which proved practicable; the largest in use has 42 spindles and takes 378 one pound cakes. The cakes are carefully fitted onto bakelite cake holders having five large holes in the center of the barrel. The time of dyeing is from 2½ to 6 hours; prolonged dyeing usually results in a few collapsed cakes but this does not necessarily mean the cakes will be unsatisfactorily dyed. Due to variable leakage, the pressure when circulation is from outside to inside is less consistent than in the reverse direction, hence the periods are run 20 minutes inside to outside, 10 minutes outside to inside, throughout the dyeing. Since thorough examination of the cakes for shade during dyeing depreciates their subsequent windability, examination is limited and excellent judgment in dyeing is required. If channelling in a cake occurs it may be corrected by hydroextracting and then continuing the dyeing, or in extreme cases by drying the cakes as well before continuing the dyeing. Examination of the cakes in white fluorescent lighting has been found best for revealing faulty dyeing. Since a rayon cake acts as a highly efficient filter, the water supply must be of the highest quality; the use of Calgon is recommended. The effective liquor-to-goods ratio at the face of the stationary threads in the cake is not over 3 to 1, therefore it is especially important that the levelling properties, rates of exhaustion and salt sensitivities be known to the dyer; highly concentrated dyes should be used even at the sacrifice of some uniformity of strength and shade from one dyestuff shipment to the next. Although the bulk of the experience (over one and one-half million pounds of cakes have been dyed) has been with direct dyestuffs, cake dyeing has also been successfully carried out on a commercial scale with naphthol, sulfur, solubilized vat, and some ordinary vat dyes; in the case of the latter type a dyebath temperature of 90° C is required which obviates the use of some dyes, particularly blues, which break down at this temperature; pigment padding of vat dyes on rayon cakes has not yet been accomplished because the surge of the reduction liquor washes the dispersed vat dyes off the fiber before it has had time to become fixed. Typical formulas for the dyeing of solubilized vat dyes are presented.

Dyeing Rate

The importance of the dyeing rate. An interpretation for the practical dyer of recent research on direct dyeing. J. Boulton. *J. Soc. Dyers and Colourists* **60**, 5–16 (Jan. 1944).

The modern concept of the dyeing of cellulose with direct dyes is briefly reviewed. The behavior of vat dyes, which is at all times a twofold process (viz. (1) heavy and instantaneous absorption on to the surface of the material and (2) gradual diffusion into the interior of the fiber), may be regarded as an extreme case of the behavior of direct dyes. The "rate-of-dyeing," comprised of each of the above mentioned actions, is a major factor in any

dyeing and may be greatly influenced by conditions of temperature, electrolyte, length of liquor, nature of dye and state of material to be dyed. The rate of diffusion into a fiber is a specific characteristic of a particular dye, differences of 1 to 2500 existing between certain dyestuffs in this respect. The effect of temperature and salt concentration on the initial "strike" and on the diffusion rate of (1) dyes which exhaust and level rapidly, (2) those which exhaust and level slowly and (3) those which exhaust rapidly but level slowly, is discussed. In order to allow himself maximum latitude for utilizing knowledge of dye characteristics, the dyer should use concentrated dyes as free from salt as possible and also water as free from dissolved salts as practicable. A simple test designed to show the exhaustion rate and the influence of salt additions on that rate, consists of dyeing a series of skeins for varying times without added salt and also for a set time with additions of increasing amounts of salt. Applied to a large number of dyes, three broad classes were found to exist, each either sensitive or non-sensitive to salt: (1) fairly deep dyeing without salt, not much affected by time, (2) gradual increase in depth of dyeing with time without salt and (3) practically no dyeing without salt, regardless of time. In order to obtain useful information about the leveling properties of dyes, a leveling test is employed which consists essentially of treating dyed skeins paired with undyed skeins in water at 90 C with and without salt and noting the tendency to strip into the water and to dye the white skein. The rates of these two processes determine the time required to transform an unlevel dyeing into a uniform and fully penetrated dyeing. Such data, combined with information from the time-salt test, provides full knowledge of the degree of control necessary for satisfactory dyeing and also can predict compatibility of dyes when used in mixtures. The most level dyeing dyes are those which diffuse most rapidly since they overcome most rapidly unequal powers of adsorption on the part of the fibers. It is believed that although salt may influence the transfer of dye from the bath to the cellulose it does not greatly influence the rate of diffusion inside the cellulose. Determination of the "time of half dyeing," t, and its significance is discussed. The visual results of the leveling test mentioned above are perhaps more readily appreciated by the dyer than the numerical value t, but the latter is a very convenient means of expressing the relative diffusion rates of direct dyes and it is suggested by the author that manufacturers characterize their direct dyes by the appropriate t value. A revised list classifying 186 direct dyes according to their half-dyeing time is appended.

Wool Dyeing

The dyeing of acid and chrome colors on wool with phosphoric acid. E. I. Noble. *Text. J. Australia* 19, 71–7 (Apr. 15, 1944).

Phosphoric acid may be used in place of formic and acetic acids with a large reduction in dyeing costs, and though somewhat more expensive than sulfuric it has other advantages which outweigh the cost factor. The principles underlying the application of the three main classes (colloidal, semi-dispersed and dispersed) of acid and chrome dyes are reviewed and practical suggestions are made. Instead of the ordinary practice of beginning the dyeing of a rapid dyeing color with a weak acid in the bath and then exhausting with sulfuric, it is considered better to commence dyeing with sufficient acid, irrespective of type, to exhaust the color and to make no addition of acid whatever. Chemically equivalent amounts of sulfuric, formic, phosphoric and acetic acids do not produce the same degree of exhaustion in normal dyeing time (1½ hours) but do so after about eight hours; equal concentrations of hydrogen ions of these acids at commercial dyeing strengths give different degrees of exhaustion for normal dying times. The amounts required of the various acids named to give 95% exhaustion in 1½ hours has been determined. In dyeing the dispersed wool dyes which normally require fairly large amounts of sulfuric acid, the use of phosphoric acid is of great advantage since very much better levelling takes place at the higher pH obtained with the latter acid.

A mixture of phosphoric acid and soda ash is a perfect substitute for acetic acid with the added advantage that the presence of the sodium dihydrogen phosphate thus formed buffers the dyebath so that the pH does not change appreciably on dilution. By dyeing at a higher pH (lower concentration of hydrogen ions) or by providing large quantities of a second anion (e.g., sulfate or naphthalene sulfonate) which reduces the extent of combination of the dye, the tendency of the heavily dyed fibers to dissociate dye into solution is increased and thus the dyeing will level up. Phosphoric acid also possesses the advantages over sulfuric acid of producing better penetrated dyeings and of causing less damage to cellulosic fibers if such are present.

Resin Finishes

Plastics and post-war clothes. Anon. *Silk and Rayon* **18**, 410–12 (Apr. 1944).

Properties which make plastics desirable for use in clothing are: resistance to water, bacteria, mildew, moths and other insects, permanence to laundering, ability to increase the wet resistance and crease-resistance of rayon, improvement of light- and wash-fastness of dyes, increased resistance to abrasion, may act as binders for pigments, and may be used as waterproof coating. Among the chief shortcomings is the undesirable brown or yellow color of many of the resins.

Creasing

Creasing of cellulose acetate fabrics. Anon. *Can. Text. J.* **61**, 33–34 (May 19, 1944).

Due to the thermoplasticity of cellulose acetate, much care must be exercised during the processing of acetate fabrics to prevent permanent creasing. The main factors are heat, pressure and tension. Cold treatments should not follow hot. Suggestions are given for minimizing or avoiding creasing effects.

Creasing of cellulose acetate fabrics. Anon. *Can. Text. J.* **61**, 33, 44–45 (June 16, 1944).

Suggestions are given for the handling of fabrics which will respond to the opening-out technique for the prevention of creasing. Among the recommendations are: The use of a curved expander bar before the material passes to the winch and then using a slow-moving reel, immediate hydro-extraction following dyeing, and careful adjustment of the jigs to insure that none of the rollers are out of line. A general method is given for removing creases that appear. Two patents, B.P. 549,369 and U. S. 2,313,173, for methods of removing creases are described.

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Aralac

Aralac's progress in the textile field. O. B. Bromley, Jr., *Can. Text. J.* **61**, 40 (May 19, 1944).

Among the important properties of Aralac are: warmth equal to wool, high resilience, ability to withstand carbonizing process (but not caustic boil-off), ability to take dyes now on market. The hand of goods made from Aralac may be varied from the sharpness of a worsted to softness of a woolen. It has so far been used mostly for dress goods, suiting, coatings, underwear, sport clothes and socks.

New Synthetic Fiber

Polyethylene—a carbide production achievement for the Navy. Anon. *Bakelite Review* **16**, 3–5 (July, 1944).

The physical properties of polyethylene are tabulated. Some of its applications are illustrated by means of photographs. This resin may be extruded as a monofilament, which shows promise as being an interesting and useful new textile fiber. Its low specific gravity, 0.92, and its low water absorption, 0.03 per cent, promise to make it a textile fiber with unique properties.

Spider Silk

Nephila Silk. Eric Hardy. *Silk J. Rayon World* **20**, 36–37 (Feb. 1944).

Post-war conditions which may arise in the Orient might make it desirable or even necessary to augment the supply of silk-

worm silk with other types. One source that shows promise is from the cocoon (not the web) of the giant Nephila spider. Other types of spiders have also been investigated as sources of silk. Some of the data and conclusions are discussed here. References and sources of further information are given.

Vinyon Properties

Vinyon: its raw material, manufacture, properties and scope. Anon. *Silk and Rayon* **18**, 261 (Mar. 1944).

Vinyon is produced from a vinyl resin which is in turn produced by the copolymerization of vinyl chloride (abt. 90 per cent) and vinyl acetate (abt. 10 per cent) to an average molecular weight of 20,000. To produce Vinyon this resin is dissolved in acetone, de-aerated, and spun in the same manner as acetate. The strength may be increased up to 400 per cent by after-stretching and annealing. The important properties are: equal wet and dry strength, low water absorption, will not mildew, low specific gravity, high elasticity and strength, stability to sunlight, good dielectric properties, chemically inert to strong alkalis and acids including hydrofluoric, insolubility in alcohols, aliphatic hydrocarbons and many other organic solvents other than ketones and certain aromatic hydrocarbons. Important uses are filter cloths, anode bags, chemically resistant clothing, etc.

Wool-Redwood Fabrics

Quantitative determination of redwood bark fiber in wool-redwood fabrics. Ernest R. Kaswell. *Am. Dyestuff Reptr.* **33**, 237–8 (May 22, 1944).

It has been found that redwood is at least partially soluble in both of these reagents. Hence it becomes necessary to introduce solubility factors properly to determine fiber composition by either the sulfuric acid or sodium hydroxide technique. Samples of redwood, wool, and of mohair were prepared and their solubilities in sulfuric acid and in potassium hydroxide determined. From these results the following solubility factors were determined for use in analyzing redwood-wool mixes.

In sulfuric acid:

Redwood	32%	insoluble
Mohair	99%	insoluble
Wool (low grade)	98.75%	insoluble
Wool Top	98.1%	insoluble

In potassium hydroxide:

Redwood	78.75%	insoluble
Wools	0.0%	insoluble
Mohair	0.0%	insoluble

Laboratory blends of the various wools and redwood were analyzed by both the sulfuric acid method and the caustic method, using the above solubility factors. It is shown that greater accuracy is obtained by means of the potassium hydroxide method than by the sulfuric acid method and therefore it is recommended that the caustic method be used for the separation of wool-redwood blends.

MISCELLANEOUS

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China's Textile Industry

A message to America from China's textile industry. Cha Chi-Min. *Textile World* **94**, 85–7; 182–4 (June, 1944).

Since the outbreak of the war between China and Japan, 90 percent of the Chinese cotton spinning and weaving industry has been destroyed by the enemy. A five-year plan for postwar rebuilding of the industry which is now under consideration in China is outlined by the manager of the Ta Min Dyeing and Weaving Co., Chungkin, China. The plan involves cooperation with America in importing American cotton, chemicals and machinery and manufacturing low cost fabrics in China for markets of the Far-East. A financing plan is suggested.

Electrostatic Dust Precipitation

Judson conquers air-borne dirt. Anon. *Textile World* **94**, 88–90 (June, 1944).

Electrostatic types of air cleaners have been installed for removal of dirt, dust and soot from the air passing through the air conditioning system at Judson Mills, Greenville, S. C. The operation of the system has resulted in dividends by reducing seconds one-quarter and by cutting in half the

amount of goods necessary to be degraded into dark shade classifications. As a result of two different installations of precipitron units, deposits of black dirt on guides in the throwing room and similar deposits on reeds in the weave room have been reduced to such an extent that trouble formerly caused by smudges on woven fabrics has disappeared. Also, an over-all production increase of 2½ percent has been attributed to the installations.

Informative Labelling

Information please. Anon. *Modern Plastics* **21**, 75–82 (June, 1944).

A discussion of the advantages of and uses for informative labelling of consumer products. The trend toward consumer education is discussed and a brief history given of the development of informative labelling. Many of the labels and tags now in use by the textile and plastics industries are illustrated. Suggestions are made in regard to the type information that should be presented on labels.

Insect Pests

Resistance of fabric and yarn to insect pests. J. R. Bonnar. *Am. Dyestuff Reptr.* **33**, 266–9 (June 19, 1944).

The members of committees on tests for "Resistance of Fabric and Yarn to Insect Pests" representing the American Association of Textile Chemists and Colorists, the American Society for Testing Materials, and the National Association of Insecticide and Disinfectant Manufacturers have presented results of cooperative evaluation studies including nearly 2500 individual tests. The Excrement Weight Method was compared with the Fabric Loss Method on different types of insect resistant treatment (both permanent and non-permanent) and on nine different types of yarn and fabric. Both excrement weight and fabric loss results were found to vary too greatly from laboratory to laboratory to be set up as standard procedure and it was the consensus of the investigators that visual damage should be the criterion, with either of the weight methods used as a check. A uniform means of reporting visual damage is being developed.

Low-Pressure Laminates

Fabrication of experimental low-pressure laminates. H. W. Collins et al. *Modern Plastics* **21**, 104–6 (May, 1944).

The methods described are not suggested as suitable for large scale production, but are purely laboratory techniques. Cloth impregnation, laminating and curing processes are described. Detailed instructions are given for the curing of various resins including: C-39, MR-1A, CR-149, Plaskon 900, and Monsanto 38691. Preparation of samples for test is also described. 6 illustrations.

Paper-Base Laminates

Potentialities of paper-base laminates as compared with other laminates. Alfred J. Stamm. *Paper Trade J.* **118**, 39–41 (May 25, 1944).

Plastics should continue to increase in importance in the coming postwar era as they have during the war period. Of the different types of plastics, the laminates might be predicted to have the greatest future possibilities. A brief comparison between the cost properties and advantages and disadvantages of laminates made from glass fabric, asbestos paper and fabric, cotton fabric, paper, and wood veneer is given. A survey shows that there is no one material head and shoulders above the others. Each has its own field of usefulness. Paper, however, seems to show the broadest scope of possibilities. Cross-banded laminated-paper plastics are now being made that equal the best of the other cross-banded laminates per unit weight, with the possible exception of the newer glass fabric laminates, in all important strength properties except impact strength and yield strength in compression. The latter can be increased at the expense of a further loss in toughness.

Glass-Reinforced Laminates

Machining glass-reinforced low-pressure laminates. Frank E. Allen. *Modern Plastics* **21**, 107–9 (May, 1944).

Detailed instructions are given for carrying out the following machining operations with glass-reinforced laminates: drilling, punching, sawing, grinding, turning, tapping and threading, milling, planning and shearing.